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Efficient literature searching: a core skill for the practice of evidence-based medicine

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Abstract *Background:* Efficient literature searching and the application of formal rules of evidence in evaluating the clinical literature are the two key skills defining the practice of evidence-based medicine. Although clinicians embrace the concepts of evidence-based medicine, most identify limited personal time as the major barrier towards its implementation into daily practice. Busy clinicians who practice evidence-based medicine identify systematic reviews and evidence-based clinical practice guidelines as very useful resources. *Methods:* This review presents a simple, easy-to-follow, three-step searching strategy that emphasises the use of powerful new PubMed features that allow clinicians to retrieve high-quality systematic reviews, clinical practice guidelines and primary studies with a single mouse click. The overall effectiveness of the process is further improved by highlighting the major

features of successful and unsuccessful literature searches. *Conclusions:* At the end of this tutorial the reader should be able to conduct efficient and effective literature searches that support clinical decision making in under 10 minutes.

Keywords Evidence-based medicine · Medline · PubMed · Review literature · Systematic review · Decision making

Clinical scenario

You are a Junior Registrar working in the intensive care unit (ICU) of a major metropolitan teaching hospital. You have just finished morning rounds, where your two Seniors spent most of the time debating the merits of steroids for the treatment of sepsis, when your Consultant turns to the team and announces, “I know how we can resolve this age-old debate. Let’s have our junior colleague perform a search and present a critical appraisal of the most recent evidence regard-

ing the use of steroids in sepsis—tomorrow before rounds.”

As your head swims with thoughts of all the other things you already have to do today, you decide that you should start working on your presentation as soon as possible. Since your ICU fully embraces the role of information technology at the bedside, every terminal in the ICU provides direct access to Medline. You stop at the first terminal you see and begin your search.

You type the term *sepsis* followed by *steroids* into the query box of the main screen, and Medline

retrieves 2,099 abstracts!!!! As the blood slowly drains from your head at the thought of searching through all 2,099 abstracts to find the most relevant papers before tomorrow morning, you sense somebody watching over your shoulder. Before you can turn around, a calm voice says "I think I can help you refine that search, and it should only take a couple of additional mouse clicks."

You turn around and realise it is the Orthopaedic Consultant, who has just admitted her first case of the day to your ICU. She pulls up a chair beside you and reaches for the mouse. With one mouse click to select a search option that retrieves systematic reviews, using your simple search terms (*sepsis* and *steroids*), she identifies 28 abstracts. "I begin all my literature searches with a retrieval of high-quality systematic reviews. More often than not, a good systematic review gives you the answer you need. Sometimes, however, a systematic review does not provide a clear answer, so I always conduct a search for new, high-quality clinical trials too." she says. She turns back to the computer and with another click of the mouse, selects a search option that retrieves high-quality randomised controlled trials, and performs a second search that identifies 79 abstracts.

Introduction

Computer-aided literature searching is one of the core skills required for the practice of evidence-based medicine (EBM). Early work conducted by key members of the EBM Working Group showed that an effective literature search, undertaken at the bedside in less than 10 minutes, was feasible in 1986 [1]. By 1990, the same group had established that after a brief training session physicians could conduct bedside literature searches that resulted in changes to decision making in 47% of their clinical queries [2]. Given this knowledge, the EBM Working Group proposed *efficient literature searching*, combined with the application of *formal rules of evidence* in evaluating the clinical literature (critical appraisal), as the two key skills defining the practice of EBM [3].

Although the role of EBM [4] and computer-aided literature searching [5] may be viewed with trepidation by some, a recent survey of general practitioners in the United Kingdom demonstrated that most clinicians welcomed the concepts of EBM [6]. Furthermore, these physicians reported that they believed research findings were useful in the management of patients, and that practising EBM resulted in improved patient care. Despite these positive attitudes towards the concepts of evidence-based medicine there are significant perceived barriers to its adoption into daily practice.

The most frequently reported barrier to implementing EBM in general practice is a perceived lack of personal time [6]. The importance of time pressure is confirmed by a survey of Australian general practitioners, who identified a lack of time as being *more important* than a lack of skills when it came to *searching, appraising* and *discussing* the implications of evidence with patients [7]. To address these perceived time issues, a number of reviews have stressed the use of an efficient, structured approach to the practice of EBM [8, 9].

In order to practice EBM more efficiently clinicians find evidence-based clinical practice guidelines and systematic reviews 'very useful' resources [6, 7]. Indeed, because there is a growing consensus that the most valid answers to clinicians' questions come from systematic reviews based on rigorous research methods, a recent editorial in the *British Medical Journal* proposed that a free-access search engine that specialised in the retrieval of evidence-based clinical practice guidelines and systematic reviews could "transform health care" worldwide [10]. Furthermore, this editorial suggested that Medline was one of the greatest gifts that America has provided to the world, and that the United Kingdom should "match Medline by funding universal free access to what might be described as a Medline of synthesised, reliable, and up to date evidence"[10].

In late 2001 PubMed (www.PubMed.org), which is the free public access search engine for the National Library of Medicine's Medline, announced the implementation of a new search filter that is optimised to retrieve high-quality systematic reviews and evidence-based clinical practice guidelines [11]. Given that Medline has indexed the *Cochrane Database of Systematic Reviews* since 2000 and the journal *Clinical Evidence* (www.ClinicalEvidence.org) since early 2002, the inclusion of this powerful search filter in PubMed goes a long way towards achieving Smith and Chalmers' [10] vision of a free-access search engine of 'synthesised, reliable and up to date evidence'.

The purpose of this review is to facilitate the conduct of efficient bedside literature searches by familiarising clinicians with powerful new PubMed features. These features are presented within the context of a simple, easy-to-follow, three-step PubMed searching strategy that highlights the elements of successful, and unsuccessful, Medline searches.

At the conclusion of this contribution, the reader will be able to: generate a series of focussed clinical questions structured to facilitate the identification of appropriate search terms; use PubMed search features to evaluate and improve upon the success of searches; find and retrieve high quality systematic reviews and clinical practice guidelines; and find and retrieve high-quality primary studies.

Step 1: focus the clinical question

A recent systematic review of the use of information retrieval systems by physicians found that *successful* literature searches tended to have a simple search statement comprised of only two to three key concepts. Conversely, most *failed or incomplete* literature searches were due to the use of inappropriate search terms and/or a failure to specify alternate terms when the initial search terms did not yield meaningful results [12]. Because the success of any literature search is integrally related to the key terms used, each search should begin with the statement of the initial and alternate terms that the searcher intends to use. The generation of a focussed clinical question is an excellent way to identify potential search terms [13].

A well-built, focused clinical question is based on the clinical problem at hand and is phrased to facilitate searching the literature for a precise answer [14]. Focussed clinical questions can be formatted to address problems concerning therapy (or exposure), diagnosis, aetiology and prognosis. Regardless of the type of problem addressed, the components of a well articulated clinical question include: (a) a statement describing the patient *population* or disease process being addressed; (b) the *intervention*, or exposure being considered; (c) the *comparison* intervention or exposure, when relevant; and (d) the clinical *outcomes* of interest (population, intervention, comparison, outcome=PICO). In the specific clinical scenario presented above, a focussed clinical question could be expressed as:

- In patients with *sepsis* (population), does treatment with *steroids* (intervention) compared with *no steroids* (comparison) alter *mortality* (outcome)?

Note that very general terms were used to formulate this initial clinical question. After the initial question has been stated, the process should be refined by using more specific, or alternative terms. For example, interest could be restricted to *adult human* patients or the term *septic shock* or *severe sepsis* could be used instead of the term *sepsis*. *Methylprednisolone*, which is a specific type of steroid, could be used instead of the general term *steroids*. Each of these modifications leads to a slightly different question:

- In patients with *septic shock* does treatment with *steroids* compared with *no steroids* alter outcome as reflected by *mortality* or
- In *adult human* patients with *severe sepsis*, does treatment with *methlyprednisolone* compared with *no methlyprednisolone* alter outcome as reflected by *mortality*?

After generating a series of clinical questions related to the problem at hand and before beginning the actual

search the searcher should express the series of questions in one single, composite statement:

- In patients/*human patients/adult human* patients with *sepsis/septic shock/severe sepsis*, does treatment with *steroids/methlyprednisolone*, alter outcome as reflected by *mortality*?

In keeping with the finding that most successful searches contain *only two or three key concepts*, the terms within this composite question should be ordered from general to more specific. In the clinical scenario above the search was begun with the simple, general terms *sepsis* and *steroids*. If this initial search had not retrieved any useful articles, or if it had retrieved too many articles, the alternative terms identified by the generation of the series of clinical questions could have been substituted for the original terms. Steps 2 and 3 show how the searcher can use PubMed features to select the most appropriate search terms from amongst those identified during Step 1.

Step 2: use PubMed clinical queries

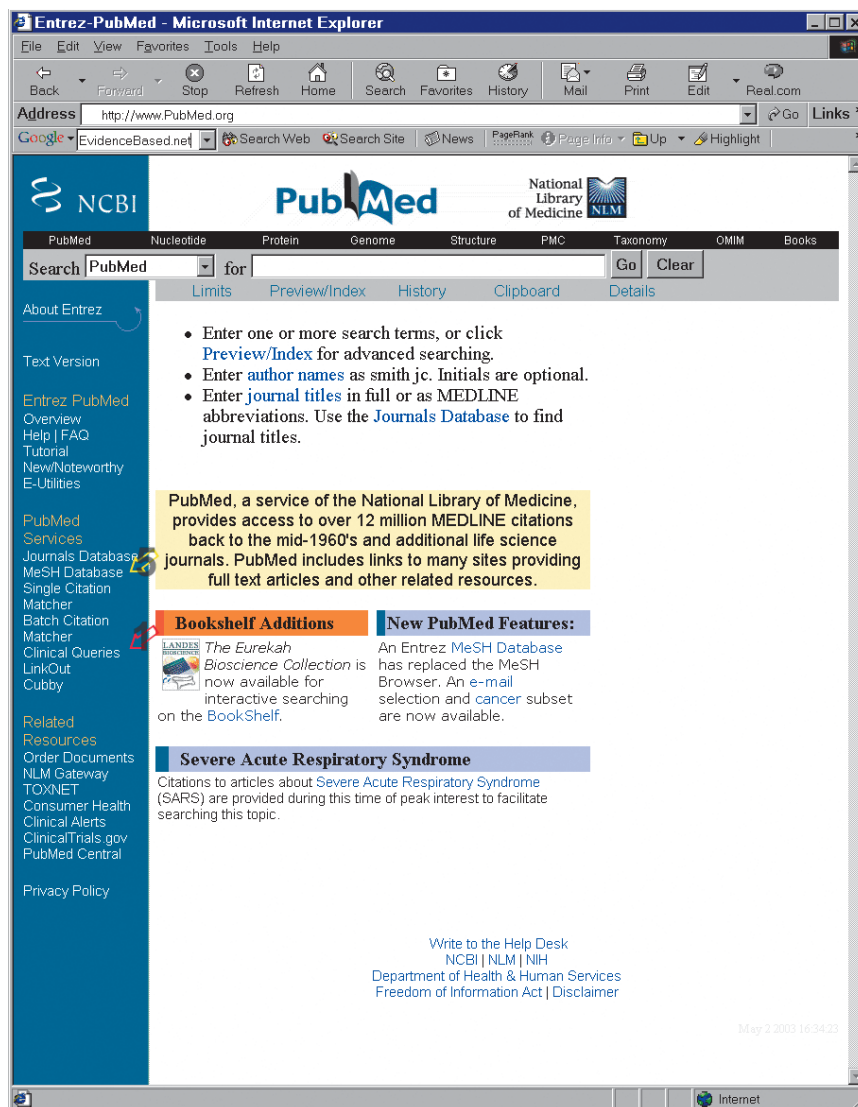
Part A: systematic review filter

A *systematic review* is a structured review of the literature that “includes a clear statement of the purpose of the review, a comprehensive search and retrieval of the relevant research, explicit selection criteria, critical appraisal of the primary studies, and reproducible decisions regarding relevance, selection, and methodological rigor of the primary research” [9, 15]. Whilst a systematic review uses a structured approach to objectively summarise the evidence, an unsystematic narrative review mixes together both opinion and evidence [16], with the evidence often selected to reflect the opinion of the reviewer.

Late in 2001 PubMed added a new search filter to its Clinical Queries section optimised to retrieve systematic reviews. In a series of test searches validated by hand searching the target journals, this filter retrieved 93% of the systematic reviews published in the Cochrane Library’s Database of Abstracts of Reviews of Effectiveness (DARE) and 97% of the systematic reviews published in the American College of Physicians-American Society of Internal Medicine’s *ACP Journal Club* [17]. Since well conducted systematic reviews serve as the building blocks for evidence-based clinical practice guidelines [18], this search filter also detects methodologically rigorous clinical practice guidelines. Although the systematic review search statement is highly complex, the use of this filter in PubMed requires only a single mouse click.

Back to the clinical scenario: To use the systematic review filter the busy Orthopaedics Consultant simply

Fig. 1 PubMed main page



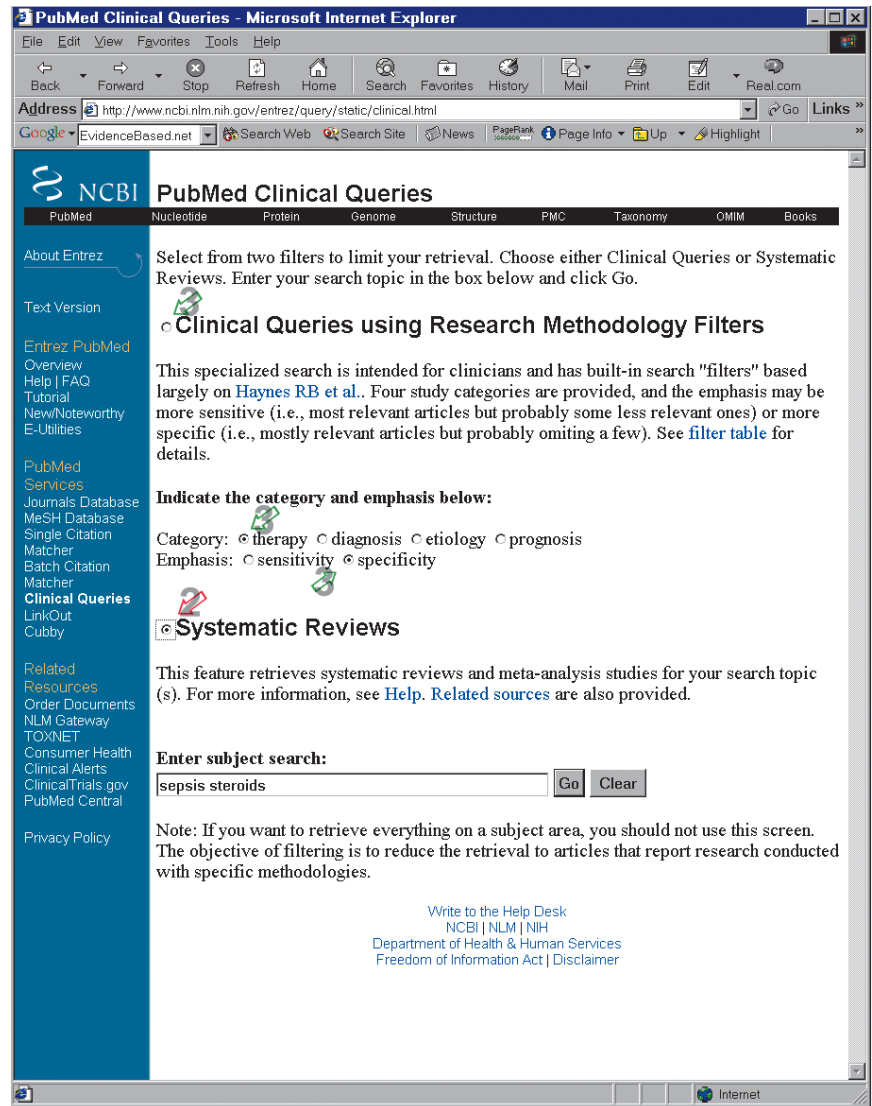
selected the Clinical Queries option from the main page of PubMed (red arrow 1, Fig. 1), clicked the radio button beside the Systematic Reviews heading (red arrow 2, Fig. 2) and entered the search terms *sepsis* and *steroids* into the Enter Subject Search box. After clicking 'go', PubMed retrieved 28 abstracts. Notice that the Search Box in Fig. 3 contains the statement (sepsis steroids) AND systematic [sb]. PubMed automatically expands the term *systematic [sb]* to the complete systematic review search statement. The complete *systematic [sb]* search strategy can be viewed on the PubMed website ('Search strategy used to create the systematic reviews subset on PubMed', http://www.nlm.nih.gov/bsd/pubmed_subsets/sysreviews_strategy.html, accessed 8 May 2003).

Part B: research methodology filters

Although a good systematic review can provide a valid answer to a focussed clinical question, it is prudent to conduct a search of the primary literature for recent, well conducted randomised controlled trials (RCTs) even when a fairly current systematic review has been retrieved. This is because methodological research suggests that a well conducted, adequately powered (large) RCT should be interpreted in preference to a systematic review of underpowered (small) trials [19]. Similarly, it is always possible that a systematic review has not been conducted to address the clinical question of interest, in which case the primary literature must be searched and appraised.

In order to facilitate the retrieval of sound primary papers relevant to clinical practice key members of the

Fig. 2 PubMed Clinical Queries page showing Research Methodology and Systematic Review filters



EBM Working Group have developed and validated a series of useful search filters that can be used to address all four types of focussed clinical questions: therapy (exposure), diagnosis, aetiology and prognosis [20]. Because each type of clinical question is best answered by a different study design, unique key search terms were identified for each category of question.

After all possible combinations of terms were evaluated, two optimal search strategies were selected for each type of clinical question: one combination of terms that focusses on the retrieval of *high-quality papers* and one combination of terms that attempts to retrieve *all possible papers*. Because a search that returns only a few, high-quality papers minimises false-positive results (retrieval of inappropriate papers), it is referred to as a *high-specificity* search. A search that returns almost all possible papers on a subject minimises false-negative re-

sults (missed papers) and is referred to as a *high-sensitivity* search. In a situation in which a high-specificity search does not retrieve any useful abstracts a high-sensitivity search should be tried. If a high-sensitivity search fails to retrieve any useful abstracts, it is likely there is a problem with the key search terms. The optimal term combinations and sensitivity/specificity for each search filter by type of clinical question can be viewed on the PubMed website ('Table for clinical queries using research methodology filters', <http://www.ncbi.nlm.nih.gov:80/entrez/query/static/clinicaltable.html>, accessed 8 May 2003).

Again returning to the initial clinical scenario: To use the Clinical Query filter to search for RCTs (the best type of primary papers to address therapy questions), the Orthopaedic Consultant simply selected the Clinical Queries option from the PubMed main page (red arrow 1,

Fig. 3 Details view of search for systematic reviews of *steroids and sepsis*

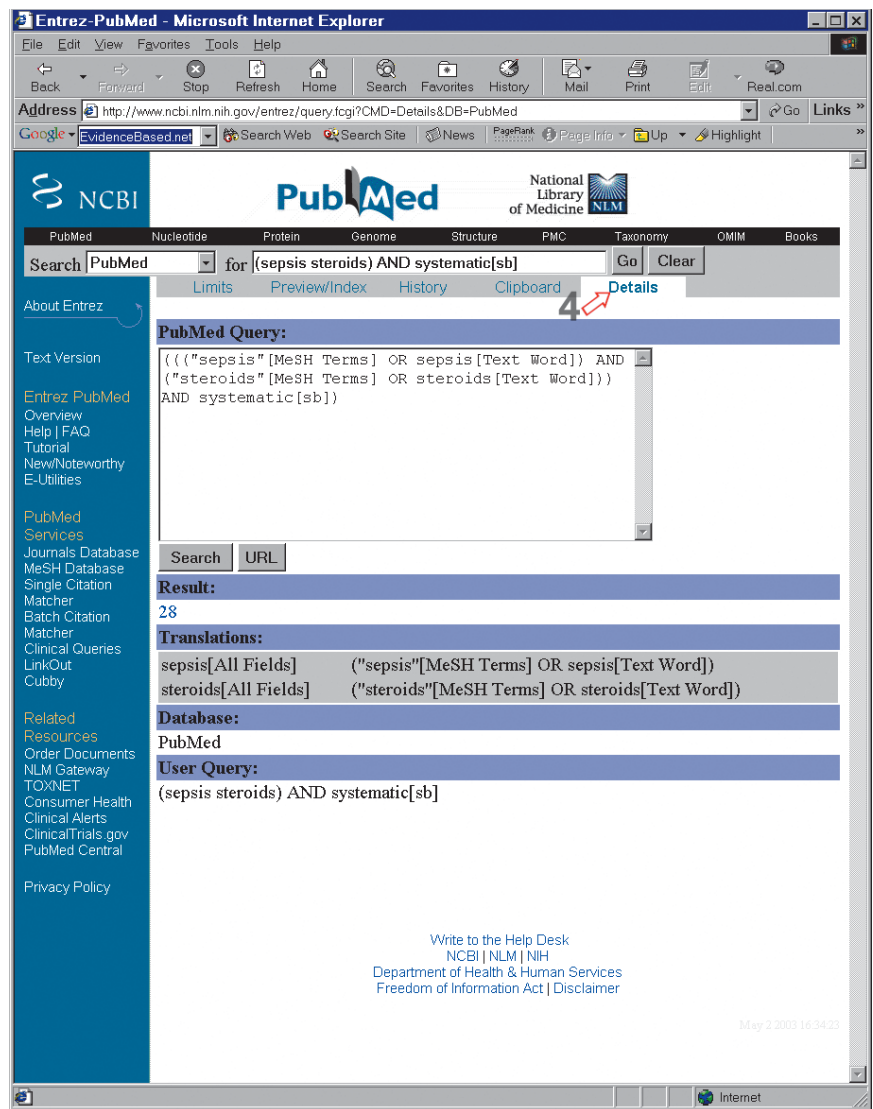


Fig. 1), clicked on the radio button in addition to 'Clinical Queries using Research Methodology Filters', chose 'Therapy' as the category of clinical question and started with a search that emphasised 'specificity' (green arrows 3, Fig. 2). After entering the search terms *sepsis* and *steroids* into the Enter Subject Search box she clicked 'go' and PubMed retrieved 79 abstracts.

Step 3: refining your search terms

The National Library of Medicine uses a controlled vocabulary, referred to as Medical Subject Headings (MeSH), to cross-reference every single abstract indexed on Medline. The use of a controlled vocabulary provides a consistent way to retrieve information that may use different expressions to describe similar concepts (Na-

tional Library of Medicine, 'Medical subject headings, MeSH, fact sheet', <http://www.nlm.nih.gov/pubs/factsheet/mesh.html>, accessed 3 January 2003). To ensure that this controlled vocabulary is reliably applied, when a paper is submitted for indexing on Medline, a professional nosologist assesses the paper and indexes it using the appropriate MeSH terms.

Most unsuccessful searches fail due to the inappropriate use of MeSH terms and/or failure to specify alternate terms when the initial search fails [12]. Although there are many different ways to ensure that a search uses appropriate MeSH terminology, the steps described below are quick, easy and do not require the retention of any specialist knowledge.

Part A: use the Details button to evaluate your search terms

The Details button (red arrow 4, Fig. 3) provides a view of the search strategy as it was actually interpreted by PubMed. Notice that the complete format of the initial clinical scenario search for *steroids* in *sepsis* is much more complex than might have been anticipated (Fig. 3). The key term *sepsis* is actually being searched as (“sepsis”[MeSH Terms] OR sepsis [Text Word]), and the term *steroids* is searched as (“steroids”[MeSH Terms] OR steroids [Text Word]). This is because PubMed automatically attempts to interpret each term entered in the query box using a MeSH Translation Table, a Journals Translation Table, a Phrase List, and an author Index, in this order. Using the Details button to evaluate how PubMed has interpreted each and every search term is an essential step towards improving search effectiveness.

The Clinical Scenario continues: Although the Registrar in our clinical scenario decided to begin her search using the general terms *sepsis* and *steroids*, she could have just as easily begun with the phrase *severe sepsis* or *septic shock* instead of the term *sepsis*. A search for systematic reviews of *severe sepsis* and *steroids* (13 abstracts retrieved), identified fewer useful articles than the more general search for *sepsis* and *steroids*.

If the Registrar had begun the clinical scenario searching with the phrase *severe sepsis*, increasing the yield of the search would have been relatively simple. Inspection of the search Details for *severe sepsis* and *steroids* reveals that PubMed automatically interprets the phrase *severe sepsis* as: severe [All Fields] AND (“sepsis”[MeSH Terms] OR sepsis [Text Word]). Note that the phrase *severe sepsis* does not map to its own unique MeSH category and is in fact interpreted as a combination of three separate terms. An excellent way to increase the yield of any search is to reduce its complexity [12, 21]. Since inspection of the search Details reveals that the term *sepsis* maps to an appropriate MeSH category, but the term *severe* does not, the best way to increase the yield of this search would be to reduce its complexity. This could be achieved by repeating the search using only the term *sepsis* instead of the more complex phrase *severe sepsis*.

Part B: use the MeSH database to refine your MeSH terms

PubMed’s MeSH Database is available on the main page sidebar menu (yellow arrow 5, Fig. 1) and is an invaluable tool for finding and resolving MeSH terms. The MeSH Database can provide a working definition for each and every MeSH term and displays the terms within a hierarchical structure called the MeSH tree. Using the MeSH Database takes only seconds and can help achieve

focus in a broad search or expand a search that does not retrieve any useful articles.

The Clinical Scenario continues: If the clinical scenario had begun searching with the phrase *septic shock* instead of the term *sepsis*, the search for *steroids* and *septic shock* would have retrieved 17 abstracts. Although increasing the yield of this search would require an additional step, it would still be a relatively simple process. Inspection of the Details for the search *septic shock* and *steroids* reveals that PubMed automatically interprets the phrase *septic shock* as (“shock, septic”[MeSH Terms] OR septic shock [Text Word]). In contrast to PubMed’s translation of the phrase *severe sepsis*, the phrase *septic shock* does map to its own unique MeSH category. Since the phrase under inspection does map to a unique MeSH category, the best way to broaden or focus this search is to use the MeSH Database (yellow arrow 5, Fig. 1) to choose an alternative, more appropriate MeSH category.

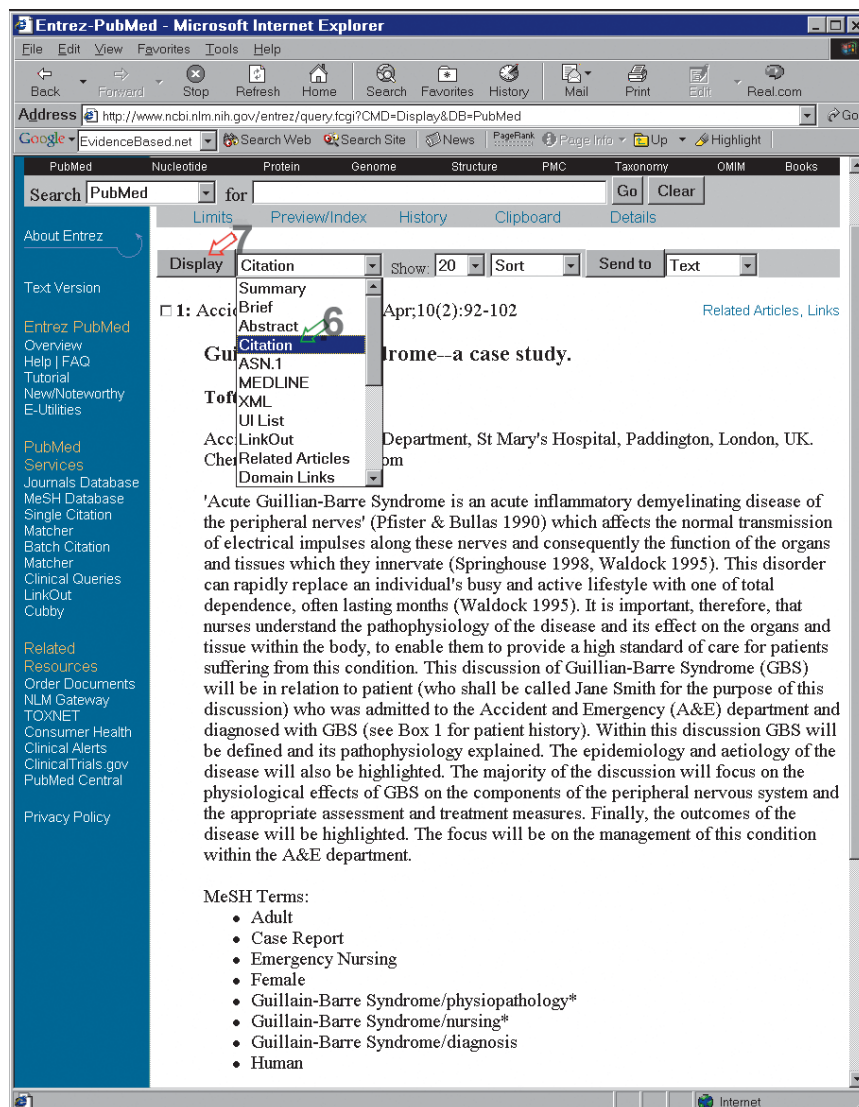
When the phrase *septic shock* is typed into the MeSH Database, the Database provides a working definition of the phrase along with a hierarchical representation of its location in the MeSH tree. The MeSH phrase *shock, septic* actually appears in more than one place in the MeSH tree: as a sub-category under the term *sepsis* and as a sub-category under the term *shock*. An understanding of the hierarchical relationship between MeSH categories allows the original search to be broadened by replacing the sub-category phrase *septic shock* with either the term *sepsis* or the term *shock*, depending on the original intent of the search. Likewise, an understanding of the hierarchical relationships between MeSH terms can be used to bring focus to a search simply by replacing a MeSH term with an appropriate term listed as a sub-category.

Part C: use the display citation feature to find MeSH categories

As stated above, one of the major reasons for search failures is the inappropriate selection of MeSH terms [12]. For example, if a search is performed in PubMed using the phrase *Guillian-Barre syndrome*, only 29 abstracts are retrieved. Inspection of the Details of the search shows the phrase is not mapped directly to a MeSH category, as might be expected, but is mapped to the terms: *Guillian-Barre* [All Fields] AND (“syndrome”[MeSH Terms] OR Syndrome [Text Word]).

In a situation such as this the Display Citation function can be used to find an appropriate MeSH category. To use the Display Citation function first select and display one of the 29 abstracts that was retrieved by this initial search by clicking on the link to that abstract. Next, display the abstract in a format that reveals the MeSH terms that were used to index the paper (select Citation from drop down menu, green arrow 6, then click the Display button, red arrow 7, Fig. 4). Inspection of the MeSH

Fig. 4 Use of the Display Citation feature to find appropriate MeSH terms



Terms listed immediately below the abstract reveals that *Guillain-Barre syndrome* is the correct MeSH term (note *ai* in the correct spelling as opposed to the *ia* that we typed). A large study of failed Medline searches conducted at the National Library of Medicine found that up to 39% of unsuccessful searches were due to incorrect entry or misspelling of search terms and/or misuse of punctuation [21]. The Display Citation feature can be used to help find appropriate MeSH categories when inspection of the search Details fails. The Display Citation feature can also be used to find the appropriate (U.S.) spelling of the intended search terms.

The core EBM skill of *efficient literature searching* can be mastered by following a three step process that includes: (a) the generation of a series of focussed clinical questions to identify potential search terms; (b) the use of PubMed Clinical Query search filters and; (c) the

use of the Details feature, the MeSH Database and the Display Citation feature to select and refine appropriate MeSH terms. The overall success rate of any search can be further improved by understanding that most successful literature searches contain only *two* or *three* key search concepts whereas most unsuccessful searches fail due to the inappropriate use of MeSH terms, failure to select alternate search terms, the use of excessively complex search statements and term misspellings [12].

Summary

Since the ability to use Medline to effectively answer clinical questions is most strongly associated with user experience with Medline features [22], we chose to emphasise the features of one specific Medline search

engine: PubMed. Although there are many other search engines that can be used to access the National Library of Medicine's Medline database, PubMed is free, widely accessible and has leading-edge, easy-to-use features. The PubMed features presented in this paper will help any clinician conduct efficient and effective bedside literature searches that have the ability to support clinical decision making [10]. For those who desire a more thorough understanding of PubMed the National Library of Medicine provides an excellent, comprehensive on-line tutorial (National Library of Medicine, 'PubMed tutorial', http://www.nlm.nih.gov/bsd/pubmed_tutorial/m1001.html, accessed 3 January 2003).

In closing, it is worth noting that the Clinical Scenario and examples presented in this paper focus on the retrieval

of randomised controlled trials and systematic reviews using the Clinical Queries features of PubMed. If one desires a greater understanding of the diagnosis, pathophysiological basis or outcome from a specific disease, the three-step process outlined above can easily be used to identify optimal search terms to conduct a Diagnosis, Aetiology or Prognosis Clinical Query. However one identifies and retrieves high-quality evidence, literature searching is only one of the core skills of EBM. In order to fully embrace this new paradigm for the practice of medicine one must always complement *efficient literature searching* with the application of *formal rules of evidence* in evaluating the clinical literature that was retrieved.

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